Appendix 9

Catfield and Sutton Fen pH Surveys 2014

1. pH surveys at Catfield Fen

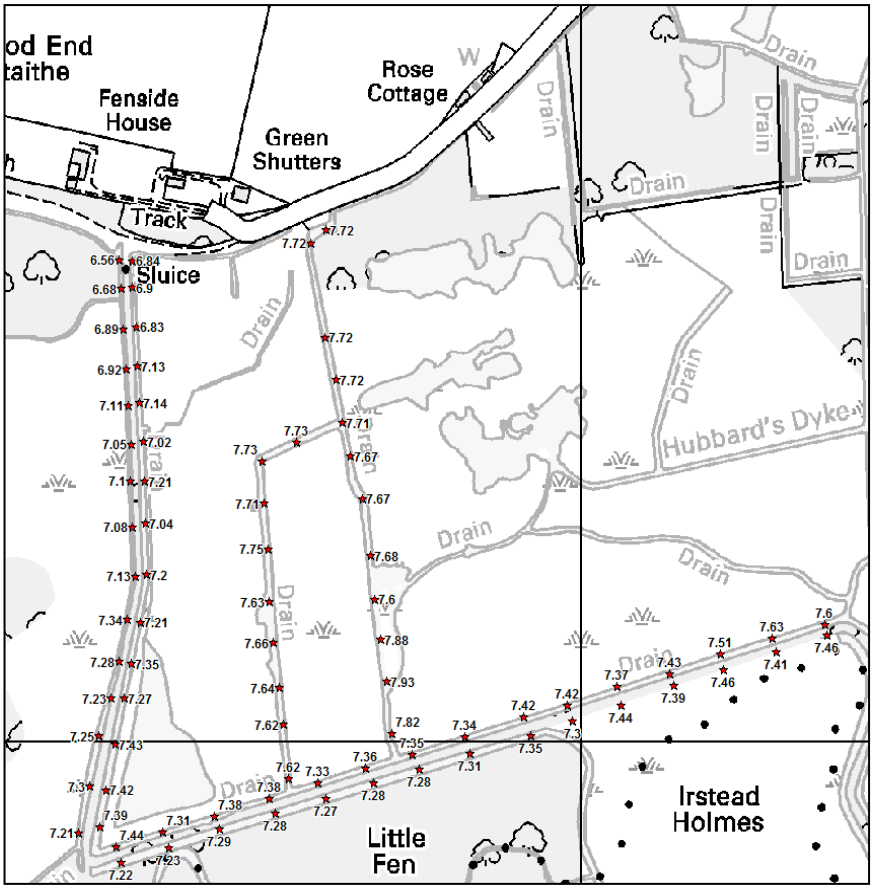
Summary:

1. To investigate general dyke pH to identify potential groundwater (or other alkaline) water inputs to the Catfield Fen dykes and to measure relative pH of internal and external dyke systems.

2nd October 2014 dyke pH survey

Method:

2. Following a period of dry weather, surface dyke pH was tested at 81 locations using a Hanna HI98129 probe from 10AM to 4PM on 2nd October 2014. The probe was calibrated with pH 7 and 10 buffers solutions before and after sampling with a shift of + 0.03pH units at pH7 and +0.07pH units at pH 10 during the day. Water was sampled by inserting the tip of the probe approx. 3cm from the water surface and approx. 50cm from the dyke edge. Areas of algae were avoided and the probe was rinsed with distilled water between each sample. Locations were recorded using a Garmin GPSmap 62 and edited on MapInfo to correct known error. Locations as mapped are accurate to within at most 10m.



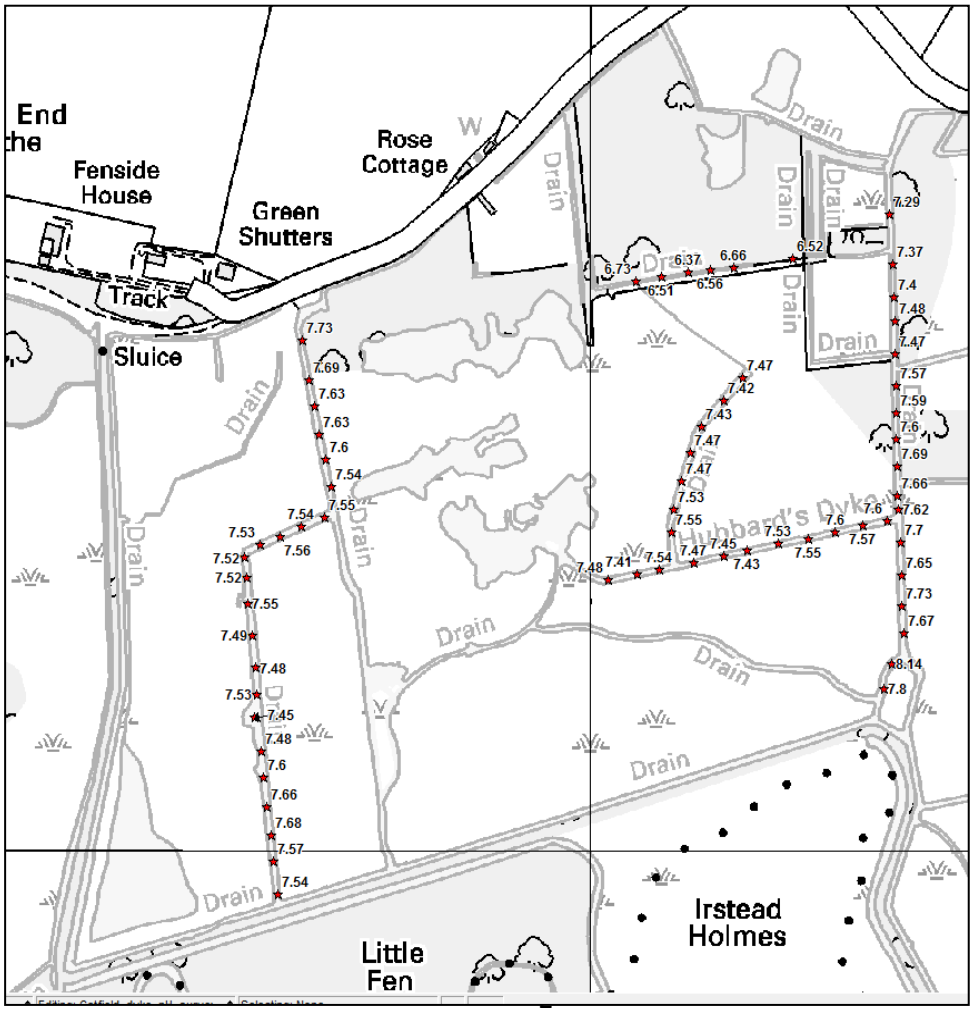
Results:

Average pH of all samples; 7.37 (n = 81)
Average of external adjacent rond: 7.20 (n = 30)
Average of internal adjacent rond: 7.29 (n = 30)
Average of other internal: 7.71 (n = 21)

10th October 2014 dyke pH survey

Method

3. Following a period of wet weather, surface dyke pH was tested at 64 locations using a Hanna HI98129 probe from 10AM to 4PM on 10th October 2014. The probe was calibrated with pH 7 and 10 buffers solutions before and after sampling with a shift of + 0.06pH units at pH7 and +0.04pH units at pH 10 during the day. Water was sampled by inserting the tip of the probe approx. 3cm from the water surface and approx. 50cm from the dyke edge. Areas of algae were avoided and the probe was rinsed with distilled water between each sample. Locations were recorded using a Garmin GPSmap 62 and edited on MapInfo to correct known error. Locations as mapped are accurate to within at most 10m.



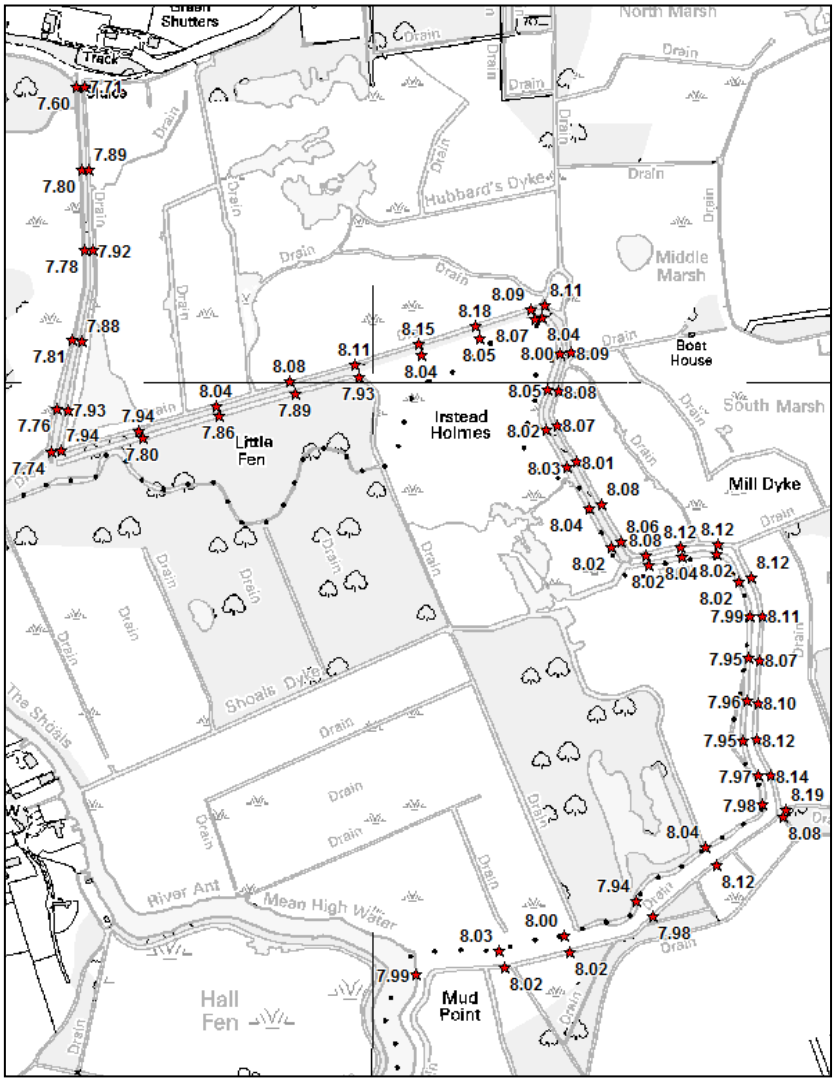
Results

Average pH of all samples: 7.46 (n = 64)
Average pH of Island marsh and sluice marsh dyke samples: 7.57 (n = 23)
Average pH of Hubbard's dyke and Eastern boundary samples: 7.55 (n = 35)
Average pH of meadow marsh dyke samples: 6.56 (n = 6)

6th November 2014 dyke pH survey

Method:

4. Following a period of mixed weather, surface dyke pH was tested at 64 locations using a Hanna HI98129 probe from 9AM to 12PM on 6th November 2014. The probe was calibrated with pH 7 and 10 buffers solutions before and after sampling with a shift of + 0.01pH units at pH7 and +0.04pH units at pH 10 during the day. Water was sampled by inserting the tip of the probe approx. 3cm from the water surface and approx. 50cm from the dyke edge. Areas of algae were avoided and the probe was rinsed with distilled water between each sample. Locations were recorded using a Garmin GPSmap 62 and edited on MapInfo to correct known error. Locations as mapped are accurate to within at most 10m.



Results

Average pH of all samples: 8.00 (n = 69)
Average pH of all internal samples 8.05 (n = 35)
Average pH of all external samples 7.95 (n = 34)
Average pH of Butterfly Conservation internal samples 8.00 (n =14)
Average pH of Catfield Hall internal samples 8.10 (n = 16)
Average pH of Sharp street fen internal samples 8.04 (n = 5)

Interpretation of dyke water pH surveys

5. The pH for the internal system was higher than the pH for the external system for all data sets. This is surprising given the base rich status of the River Ant and relative isolation of the external system from the river. This may imply a source of base rich water within the internal system. It has been proposed that if input from the external system to the internal system was increased through sluice operation, this may help alleviate the base depletion occurring within the internal system, but this data suggests further work is needed to understand what impact this would have on the pH and base status of the internal system.

6. There appears to be decreasing trend in pH within the external system with distance from the dyke connections to the River Ant via Shoals Dyke. This is most pronounced along the dyke to the East of Great Fen and implies that there is poor connection between Great Fen and Barton Broad to the North and that the dykes (and surrounding fen vegetation) intercept much of the base richness before the water reaches the Northern sluice.

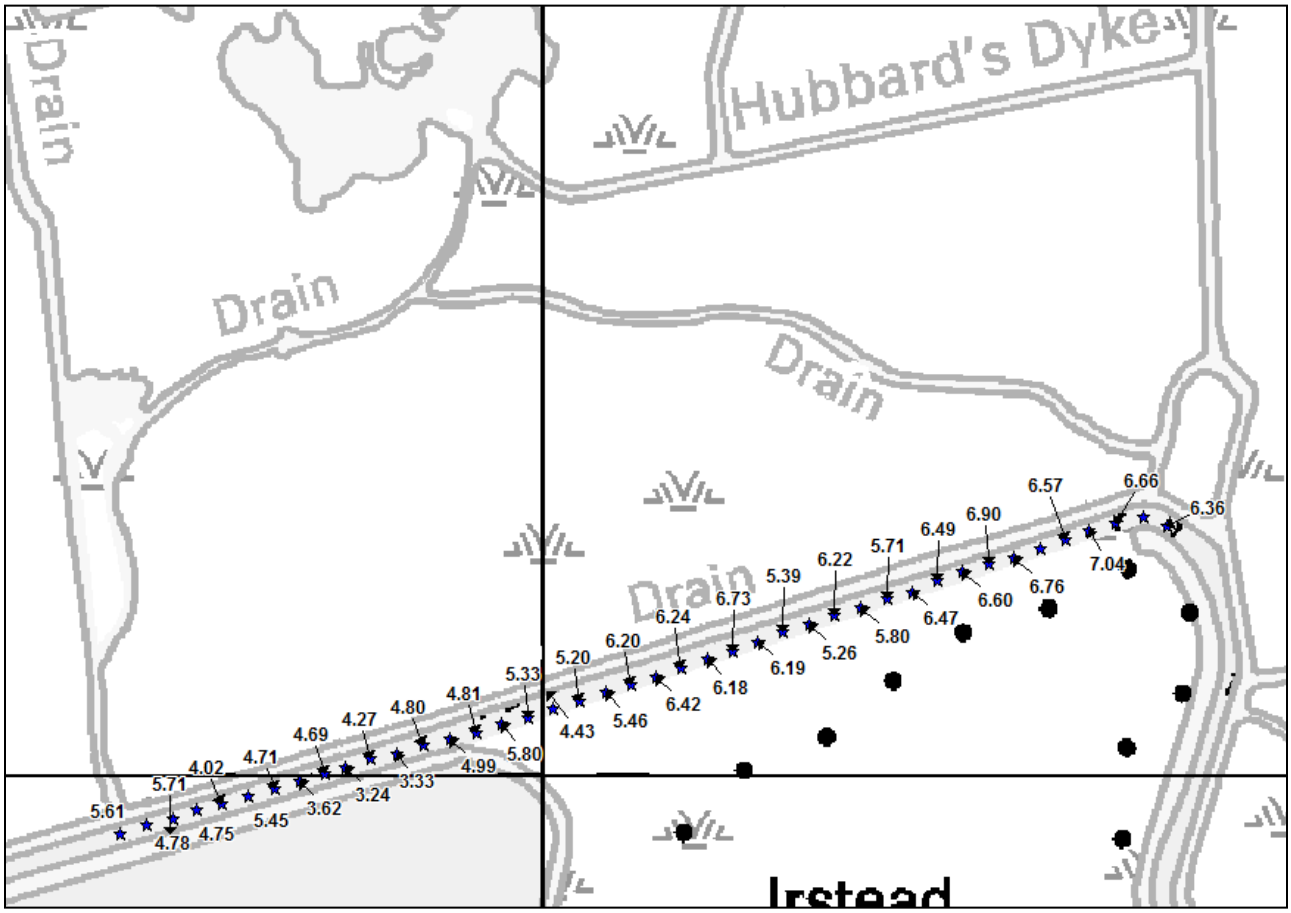
7. The highest pH values are toward Catfield pump and Catfield Hall Estate. There are known connections between the crag and the dykes in these locations and this data supports the hypothesis that base rich crag water feeds the dykes and is important in maintaining their base rich status. There are also some slight increases toward Catfield Staithe, where there is also connection with the crag, though this area is known to be influenced by surface water runoff.

Ditch slubbing pH

8. Dyke pH samples presented above showed increase pH near to the Catfield Mill. There is a known crag connection here (there is crag material on the rond that was dug from the dyke course). To identify if the sediment, as well as the dyke water, showed increased pH in this area that may suggest an extended period of crag input, the pH of the recently slubbed ditch sediment was sampled.

9. Part of the interior rond ditch to the west of Catfield Mill was slubbed during the week of the 13th October. On 6th November 2014, using a Lutron Ph-220S soil pH probe, the slubbings were tested for pH at approximately 10m intervals by inserting the probe 5cm into the surface of the sediment. The probe was washed with distilled water between each sample and the sample was taken from the centre of the rond for each point. Location was recorded by pacing 10m intervals from the fixed

point of a birch tree near the mill to the fixed point of the N-S dyke from Catfield staith and mapped using MapInfo with the aid of an aerial photograph.



Results

10. There is a clear trend of decreasing pH away from the Mill with a possible increase toward the East and the N-S dyke. This is similar to dyke water pH readings shown in 1.1 and 1.3 above and is further indication of a base rich source near to Catfield Mill where there is known to be connection with the crag. The sediment results are likely to demonstrate a long term input (unlike the surface dyke readings that could be short term).

Fen surface water

11. Recent identification of *Potamogeton polygonifolius* in Sluice Marsh has implied that surface pH has changed since the 1980s when *Potamogeton coloratus* was known to occur. To confirm that surface pH was indeed below 7 and within the tolerance range of *P.polygonifolius*, surface water pH tested and mapped.

Method

12. On 15th September 2014, using a Hanna HI 981289 probe, 78 surface pH readings were taken by inserting the probe tip at 3cm depth, areas of algae were avoided and the probe was rinsed between each sample using distilled water. The probe was calibrated with pH 4 and pH7 buffer solutions before and after sampling with a shift of -0.10 at pH 4 and -0.02 at pH7.

Interpretation

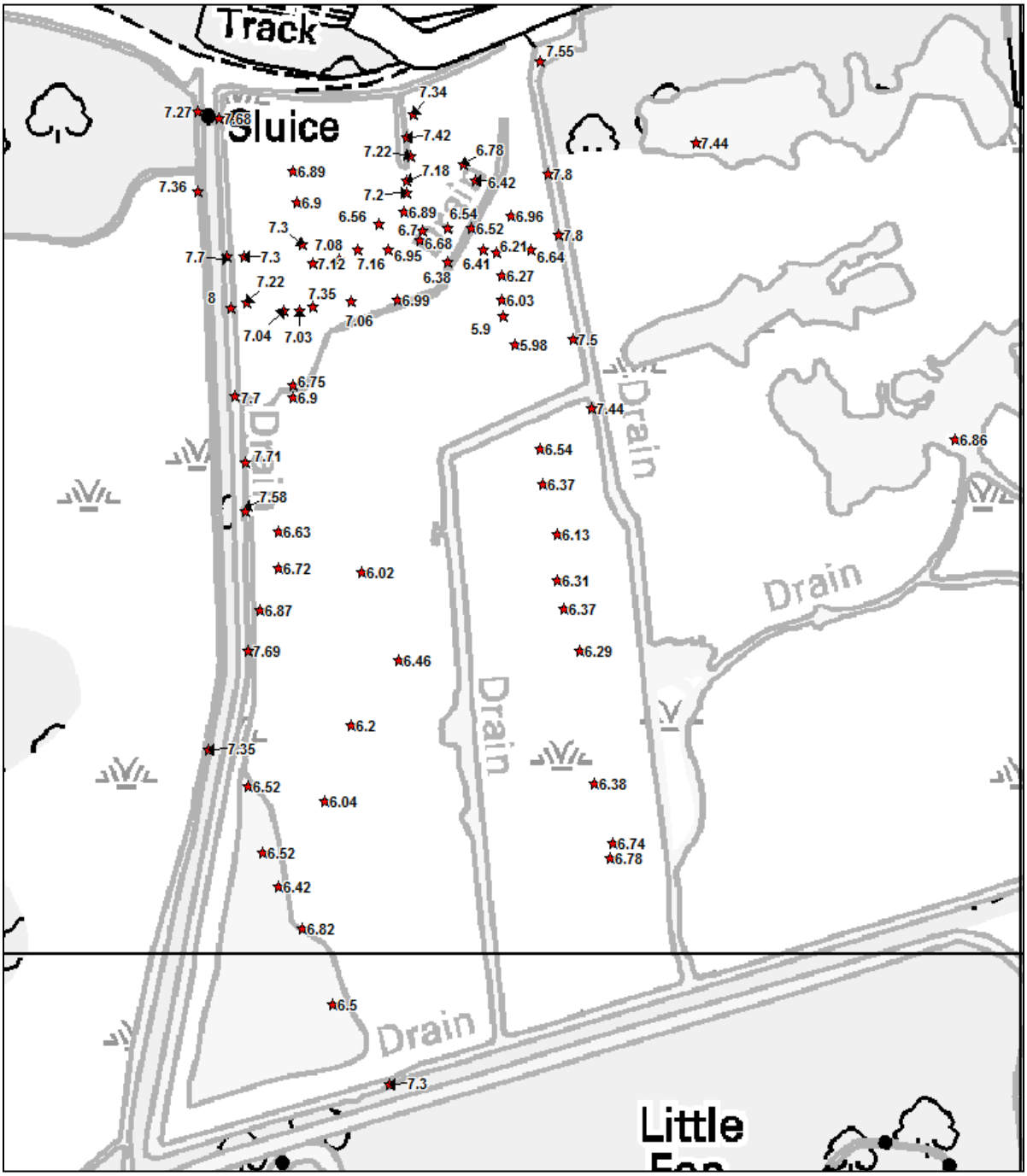
13. The majority of the samples and fen area is within the pH range suitable for *P. polygonifolius*, which was encountered quite widely within Sluice Marsh and there are small areas (most notable the extreme north west corner) where pH is suitable for *P. coloratus*. Despite suitable management and available habitat (bare peat on deer tracks and management operations) there was no *P. coloratus* found here during 3 separate surveys in 2014.

14. Dyke pH is always higher than fen pH and there is some apparent influence from dyke water on pH of adjacent fen, but there is a rapid decrease in pH away from the dykes and therefore a general trend of decreasing pH toward the compartment centres.

15. There is anecdotal evidence of a 'spring' during the 1980s toward the northern part of Sluice Marsh and this area is currently the most alkaline part of the area surveyed. This could indicate a continuing input of base rich water or latent bases within the fen peat from historic input.

16. Island Marsh has poor dyke connection, surrounded on three sides (north, east and west) by high peat banks, whereas Sluice Marsh has free connection with dykes with banks in the south west corner (around the turf pond) only. However, this does not appear to have impacted pH, with pH on Island Marsh within a similar range to Sluice Marsh. Some areas of the fen with very good connectivity to the ditches are particularly low in pH.

17. Increased connectivity with dykes has been suggested as a measure to increase alkalinity. The data presented here suggests that pH is increased by proximity to dykes, but only marginally and pH drops rapidly with distance from dykes. Creation of new dykes is unlikely to significantly increase pH of fen surface water without an intensive network of new dykes that would be ecological unjustifiable due to loss of open fen to dry banks and interference with the archaeological feature of the undug peat in this area.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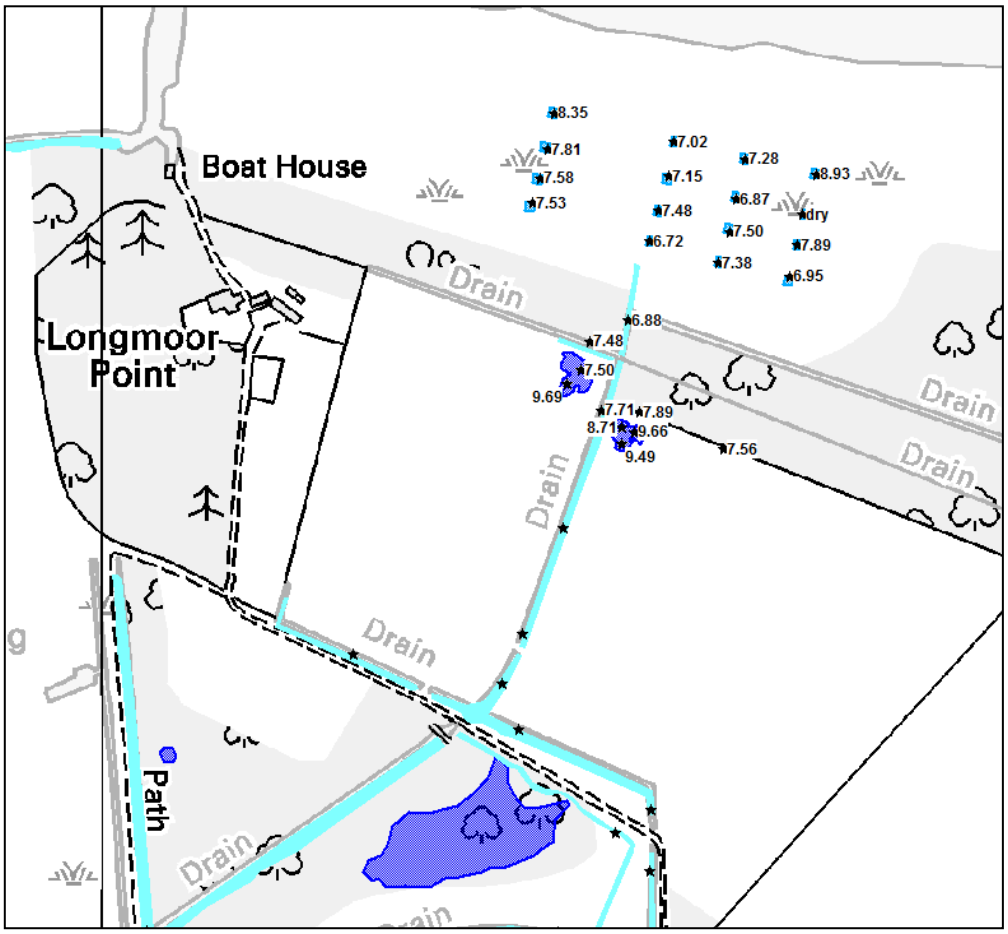
2. pH surveys at Sutton Fen

Introduction

18. In order to better understand water inputs to Sutton Fen, the pH of pools and dykes located on the upland edge of Sutton Fen and extending into the fen compartments was sampled. This particularly focussed on the Sutton Broad area which has been considered with the Environment Agency's groundwater model used to assess two water abstraction licence renewals in the Catfield-Ludham area. The main aim was to determine if there were any indications of direct groundwater inputs to Sutton Fen.

Investigation into pH readings on Sutton Broad



19. Following a period of dry weather, surface dyke pH was tested at 26 locations on the landward edge of, and within, the Sutton Broad area of Sutton Fen. Readings were taken using a Hanna HI98129 probe from 10:00hrs to 16:00hrs on 6th August 2014. The probe was calibrated with pH 4, 7 and 10 buffers solutions before and after every 4 samples. This calibration found a maximum drift of 0.2pH units with an average of 0.1, no correction for pH drift is attempted here. Water was

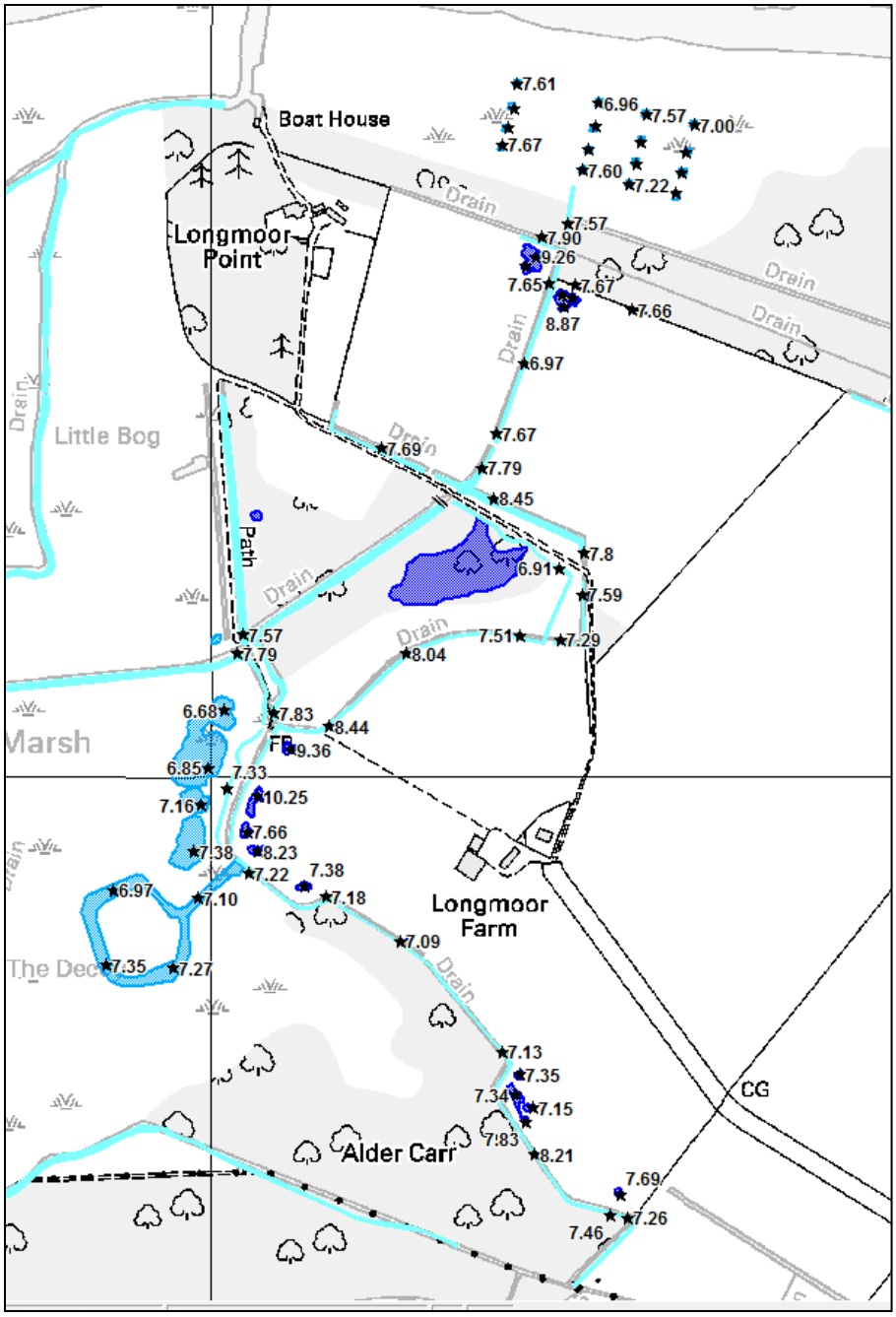
sampled by inserting the tip of the probe approximately 3cm beneath the water surface and approximately 50cm from the dyke or pond edge at 3 points for each sample site. An average reading was then calculated. Areas of algae were avoided and the probe was rinsed with distilled water between each sample. Locations were recorded using a Garmin GPSmap 62 and edited on MapInfo to correct known error. Locations as mapped are accurate to within at most 10m and mostly to within 1m.

20. Results:
    - One sample was too dry to test.
    - Average pH of all samples: 7.80 (n = 25)
    - Average pH of 'upland ponds': 9.01 (n = 5)
    - Average pH of upland dykes: 7.58 (n = 3)
    - Average pH of peat dykes: 6.88 (n = 1)
    - Average pH of peat turf ponds: 7.50 (n = 15)

Investigations into pH readings on Sutton Fen

21. Following a period of damp weather, surface dyke pH was tested at 55 locations using a Hanna HI98129 probe from 10:00hrs to 16:00hrs on 6th August 2014. The probe was calibrated with pH 4, 7 and 10 buffers solutions before and after every 4 samples. This calibration found a maximum drift of 0.4pH units with an average of 0.1, no correction for pH drift is attempted here. The drift was mostly at the pH 10 end, so it is likely that some of the higher values are overestimates by up to 0.4pH units. Water was sampled by inserting the tip of the probe approximately 3cm below the water surface and approximately 50cm from the dyke or pond edge at 3 points for each sample site with an average taken for presentation below. Areas of algae were avoided and the probe was rinsed with distilled water between each sample. Locations were recorded using a Garmin GPSmap 62 and edited on MapInfo to correct known error. Locations as mapped are accurate to within at most 10metres and mostly to within 1m.

22. Results:
    - Average pH of all samples: 7.63 (n = 55)
    - Average pH of 'upland ponds': 8.20 (n = 12)
    - Average pH of upland dykes: 7.57 (n =22)
    - Average pH of peat dykes: 7.37 (n =7)
    - Average pH of peat turf ponds: 7.24 (n = 11)



Interpretation of dyke water pH surveys

23. The combined average pH between the two surveys is 7.68. This is a high pH value given that many of the sampling points are isolated from the alkaline influence of the River Ant and Sutton Broad. This provides a very strong indicator for significant alkaline groundwater input. The highest individual pH readings and the highest averages are for the upland ponds and some of the upland dykes. This is not conclusive evidence for groundwater input to these water bodies, but provides

support for the theory that there are alkaline inputs into the site. The sampling points also provide an indication of where to focus further investigations.

24. The peat turf ponds and peat dykes vary from slightly acidic to moderately alkaline and this may imply variation in the significance of different water types to different parts of the site. The upland dyke readings support this, with a variation of over 1 pH unit within <100m in places. This corresponds with vegetation observations, as some dykes support species indicative of base-richness (*e.g. Chara* spp.) whilst other nearby ditches lack such indicator species.

25. The values exceeding pH 9 are remarkable and require further examination. However, these strongly indicate alkaline inputs and potential groundwater upwelling. This is particularly the case for the upland pools that are completely isolated from river water inputs.

26. The pH values exceeding pH 8 on Sutton Broad are surprising and require further examination, the River water that accesses Sutton Broad is below pH 8 so again these high values suggest an alternative source of water input.

27. The pH values below 7 in some parts of the peat fen suggest isolation from base-rich sources, which is surprising given the generally very good connection of the site by ditches and a regularly above surface water level during the winter allowing penetration of river and dyke water into the open fen. It is possible that this could indicate input of base-poor groundwater at the perimeter of the floodplain, as is known to occur at some other sites in the Broads.

28. In summary, the data has highlighted a number of areas for investigation. The remarkably high pH readings for the upland ponds are notable, as well as the more neutral readings within parts of the main fen. However, the hydrology of Sutton Broad and Sutton Fen has been poorly studied. Groundwater inputs could be significant and complex and could be critical in maintaining the complex vegetation communities present. In the context of understanding the risk posed to Sutton Fen from activities such as water abstraction, further investigation to better understand the hydrological regime of Sutton Fen is essential and will be explored further with the Environment Agency and Natural England.